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# Delphi Austria: An Example of Tailoring Foresight to the Needs of a Small Country

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# **Delphi Austria: An Example of Tailoring Foresight to the Needs of a Small Country**

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## **Keywords**

Technology Foresight, Delphi method, small country, Austria, innovation, technology policy, implementation

## **Abstract**

The world-wide diffusion and recognition of Technology Foresight suggests that it is of value for quite diverse types of economies and societies. Its merit as an important tool of strategic intelligence for policy-making also in small countries and transition economies depends on a careful tailoring to specific needs. Practice of Foresight is rather diverse also among small countries, but approaches tend to be more selective in scope, have more specific goals, and put greater emphasis on demand aspects than in bigger countries. Austria's first systematic Foresight programme (completed in 1998) is an example of an innovative approach adapted to the needs of a small country. This contribution shows how "Delphi Austria" was tailored to a small economy which had undergone a successful catch-up process and how the Foresight process as well as its results have been utilised.

The specific goals of Delphi Austria and its approach are explained as a selective, demand-, problem-, and application-oriented Foresight exercise with a number of innovative elements. It has been built on a series of preparatory studies, expert panels, and two parallel large-scale Delphi exercises: a Technology Delphi in conjunction with a Society and Culture Delphi. Experiences with some other innovative elements are outlined: the modification of the classical Delphi towards a decision Delphi; a broader definition of the expert base; the focus on technological as well as organisational innovations; a higher degree of "finalisation" of measures; and the application of a so-called "mega-trends section" in a multiple function.

The focus of the Austrian Technology Delphi has been on the following subject areas: Tailor-made New Materials (focus on metals); Production and Processing of Organic Food; Environmentally Sound Construction and New Forms of Housing; Lifelong Learning; Medical Technologies and Supportive Technologies for the Elderly; Cleaner Production and Sustainable Development; Mobility and Transport.

The results of the Foresight programme are built on a sufficiently broad basis of expertise to be used as an important information source for technology policy-makers as well as other actors of the innovation system, in companies and research institutions. The process of involving a great number of these actors, either as members of one of the panels developing the contents of the Delphi questionnaires or as participants in the Delphi surveys, has already been a deliberately promoted and valuable result of the whole Foresight programme. It has stimulated co-operation and networking which is seen as a strengthening of the national innovation system. Delphi Austria has also raised Foresight awareness and triggered one or the other sectoral Foresight project. In addition to this, it is shown that the results of Delphi Austria have had considerable impact in research and technology policy. They have directly influenced the start of new support programmes (in the field of cleaner production) and measures to support cluster building (food production). And they have been utilised for a newly created technology policy instrument, a programme named K plus, designed for promoting “competence centres” (centres of excellence): most of the proposals selected are in fields which have been identified as promising in the Delphi study.

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# I Introduction

It is widely accepted that science, technology and innovation have become more important for today's economies and societies than ever. This clearly implies a key role for technology and innovation policy. But the question how these policies should look like for an individual country in order to achieve economic and social progress is not at all an easy one. Several factors make the design of appropriate policies to a highly demanding task which requires strategic intelligence:

- Increasingly liberalised global markets and global enterprises intensify the competitive pressure for all economies and call for strategies tuned to the situation of the specific country and region.
- The traditional rationale for technology policy has been changing. Advances in economic theory have extended the view from mere "market failure" to "systemic failure", the lack of coherence among institutions and incentives in complex innovation systems.
- The better understanding of innovation and technology diffusion processes calls for policies which are capable to respond to a variety of challenges (Kuhlmann et al. 1999, 7pp.) such as: the changed nature of technological innovation processes necessitating inter- and trans-disciplinary research; the growing importance of the non-technical, "soft side of innovation"(design, human resource management, consumer behaviour); the transition from "mode-1 science" to mode-2 science", a far more demand driven mode of knowledge production (Gibbons et al. 1994); and hence the increasing pressure to produce results in terms of concrete contributions to the solution of societal problems and to increased competitiveness of national economies.

More recent efforts to improve inputs into the design of effective technology policies have among others concentrated on instruments such as policy evaluation. Nowadays Technology Foresight is more and more recognised as a useful policy instrument and source of strategic intelligence. It has been defined as "... the systematic attempt to look into the longer-term future of science, technology, the economy and society, with the aim of identifying the areas of strategic research and the emerging of generic technologies likely to yield the greatest economic and social benefits" (Martin 1995, 140).

Some overriding trends have become visible along with the remarkable upswing of Technology Foresight during the last decade when it was establishing itself as a key policy instrument (Gavigan/Cahill 1997; Grupp/Linstone 1999):

- In contrast to earlier periods one can observe a *proliferation of foresight activities practically among all sorts of economies*, not just among the leading big industrial countries: also among smaller countries as well as among developing countries and transition economies;
- *Foresight* is no longer undertaken with the claim to *forecast* or predict a certain future situation but recognises the possibility of alternative futures and also tries to shape or create certain paths of development;
- the foresight *process* with its stimulation of communication and future orientation among the actors of the innovation system is regarded at least as important as the *outcomes* in terms of identified areas of strategic research and emerging generic technologies;
- accordingly, the function of mobilising and "*wiring up*" *national innovation systems* adds to the function of informing science and technology policy-making, e. g. for purposes of priority setting (Martin/Johnston 1999);
- increasing attention is being paid to the *socio-economic embedding* and demand aspects of emerging technologies;
- finally, with the growing diffusion of national Technology Foresight studies in Europe and indeed on a world-wide scale, a *differentiation and blending* of approaches, tailored to different sets of objectives, is occurring.

The paper starts with a look at the relevance of Technology Foresight for countries and economies of different size and development stage before giving a brief overview of practice, particularly in small countries. It then concentrates on specific characteristics of the Austrian Foresight programme as a recent example in Europe. The examination of the Austrian case emphasises the necessity – as well as possibility – to tailor the design of a Technology Foresight according to the specific situation and needs of a country. Austria's approach is that of a small country which has undergone a very successful economic catch-up process after World War II. Her Foresight exercise was definitely oriented towards responding to societal needs, the search for niches within world-wide technology trends where Austria could expect special opportunities to gain a leading position in the mid- and long-term and corresponding prospects for product demand.

## 2 The Relevance of Technology Foresight for Different Economies

The question to what extent Technology Foresight and in particular the goals and approaches established by big and highly industrialised countries are relevant for other economies is certainly important. Over decades foresight studies had been the domain of a few big players among developed countries, notably Japan with great regularity and the USA as the pioneer. In the nineties small countries have begun to move at the front stage of Technology Foresight and indeed make up a substantial part of the recent proliferation. But also newly industrialised and developing countries as well as transition economies have become increasingly interested in Technology Foresight.

The specific situation of *small countries* has a long research tradition (Soete 1988). According to Katzenstein (1985) one has to acknowledge small states as a category of their own ('small' is defined here by a population size below 20 million). From an economic point of view, openness of the national economy, production for small segments of the world market, adaptation pressure exercised by economic 'giants' and selective government interventionism are characteristic elements. Further characteristics such as stronger dependence on foreign trade, more limited resources for R&D and a disproportionate spending on basic science rather than on applied R&D may be added. A second part of Katzenstein's argument is that the economic openness and vulnerability of the small European states has favoured neo-corporatist political systems (which are less common in larger countries) and that both sets of characteristics together shape the politics and policy of industrial adjustment. While further research has led to some refinements and concentration on socio-institutional differences among small countries, the fact that they are under stronger pressure to specialise and that their adjustment policies will have to include an explicit 'technology' dimension is most relevant here.

This situation suggests that for small countries Technology Foresight can indeed be an instrument to cope with these demands but that the approach would seem to require an appropriate tailoring to more specific goals: Rather than identifying emerging technologies of strategic relevance across a broad spectrum (as appropriate for big countries), developing or redirecting *technological specialisation* strategies and matching *national potentials* with *economic opportunities* and *societal demand* are crucial for small countries.

For *developing countries* the situation and problems are certainly of a different nature, although some of the distinctive features of small countries may be given in more extreme forms. Even if they might see themselves less in a position to compete in technology development, there are rea-

sons for them to be interested in using advanced technologies, in identifying and realising their national potentials to apply these within the economy in a future-oriented perspective, in stimulating key actors and institutions to contribute to this, and in informing their future policies in this connection on the national level. Indeed, a *growing interest* in Technology Foresight is evident among developing countries: *Thailand, South Korea, Malaysia, Indonesia, South Africa, Brazil and Mexico* are examples with activities in this field. The ways Foresight is being applied by small countries and their experiences should in some respects be also a useful source for developing countries.

*Transition economies* in Central and Eastern European Countries (CEECs) are again another type of economic systems with different sorts of issues and problems. One common set of aspects is the shrinking of R&D systems and the organisational, functional and funding restructuring these systems undergo. The rationale for Foresight as an instrument for science, technology and innovation policy in the CEECs could be providing a mechanism to address structural problems and opportunities, helping policy to identify and respond to crucial linkages within the national innovation system. It also offers a mechanism to address trade-offs between different objectives (growth, competitiveness, sustainable development, equality) and a mechanism to depoliticise the process of S&T policy making. A specific feature suggested by economists is putting emphasis on absorption and transfer rather than on generation of technology at the present stage (see Radosevic 1999, 1997).

Many of the CEECs are small countries for which the approaches of countries with similar size are also of interest. Out of the group of small countries in *Europe*, the Netherlands were one of the first to carry out a major “Technology Foresight Experiment” with a study commissioned to the Science Policy Research Unit (SPRU) at the University of Sussex in 1988. It served as a preparation for area-specific foresight exercises which were started by the Ministry of Economic Affairs with mechatronics in 1989 and followed by six similar studies on adhesion, chipcards, matrix composites, signal processing, separation technology and production technology (OECD 1996). An evaluation of impacts led to the design of a knowledge transfer program oriented at SMEs and to another major Technology Foresight titled “Technology Radar” in 1997/98. It identified technologies of strategic importance for the Netherlands and focused on the needs of business and industry (Ministry of Economic Affairs 1998).

Ireland has published the results of her first Technology Foresight exercise after a process of 12 months (ICSTI 1999) and in Austria the first national Foresight programme was completed in 1998 (it will be further examined in the remainder of this article). Already in the early eighties, Sweden, Norway and Portugal have made their first steps in the area of Foresight (cf. Gavigan/Cahill 1997). Towards the end of 1998, Sweden launched a new Technology Foresight project on eight quite broadly defined areas. Finland which has started a foresight process with the “Technology Vision” project in 1996 is preparing a further sector study, after a foresight in the food and drink industry, in the chemical industry. As the first out of CEU transition economies, Hungary has undertaken a major Technology Foresight project which started in 1997. Combining a panel and Delphi approach the Hungarian Foresight Programme “aims at creating sustainable competitive advantage and enhance the quality of life by bringing together business, the science base and government to identify and respond to emerging opportunities in markets and technologies” and “should result in a national innovation strategy”(Havas 1998). In the meantime other small countries have also carried out Foresights or are planning to do so, such as Denmark, Estonia and the Czech Republic.

Further examples could be added from other continents, e. g. Singapore in Asia. Already in the late eighties, *Australia* had also embarked on prospective studies and applied priority setting mechanisms. A first comprehensive foresight exercise at national level “examined possible national and global changes to 2010 and Australia’s key future needs and opportunities that rely on, or could be significantly affected by, scientific developments and the application of technology” .... “with an emphasis on demand-pull” (ASTEC 1994; OST 1998: 87). *New Zealand* has also some experience

in applying foresight for identifying international leadership opportunities in areas of national strength and for priority setting after two exercises carried out in 1992 and 1995. Planning for a further foresight project started in 1997, this time with greater emphasis on consultation of end-users of science and technology (Martin/Johnston 1999).

To identify common trends in the foresights conducted in all these small countries can best be attempted using a set of criteria developed by Martin and Irvine (Martin 1995). It means to look at characteristics such as those of the performing organisation, specificity, functions, orientation of research, 'intrinsic tensions', time-horizon and methodological approach. To put it short: evidence from a number of well documented foresight exercises indicates that even among small countries the approaches are quite varied. However, as a tendency, some *common traits* may be pointed out:

The *goals and scopes* of foresight exercises are more frequently oriented at specific national conditions and the identification of niche potentials. *Time horizons* are less long-term but more often around 15 years. More and more emphasis is laid on the value of the foresight *process* itself as a means to stimulate communication, mutual learning, innovation-oriented consensus and co-ordination among the actors within national innovation systems. Mobilising innovation awareness rather than limiting the function of foresight to priority setting is prevailing. Decentralised and *bottom-up* approaches tend to be favoured and combined with central steering agencies, usually at *national S&T policy* level. To some extent a broadening of the expert base along with an integration of socio-economic *demand* and impact factors into foresight designs is observable. A stronger orientation towards the implementation, the applicability of results and the transfer to SMEs is also more typical for small countries. Finally, a variety of methods is applied including the use of expert panels, widespread consultation, lists of strategic technologies, scenarios and also quantitative models, but some preference for the *Delphi* method is also visible. Many of these characteristics more typical for small than for big countries are most pronounced in the Austrian Foresight exercise.

### 3 Goals and Approach of the Austrian Foresight Programme

Austria's decision to undertake a Foresight exercise came out of the following situation (Tichy 1999): The country had undergone a successful *catch-up process* from a largely destroyed economy by the end of the Second World War to a position among the leading industrial countries. The closure of the income and technology gap had relied on importing foreign technology. With the position achieved in the eighties, a *policy change* to master the difficult transition from a technology importer to a technology developer in promising future markets was perceived as highly necessary. As Austria is still specialised on a broad range of traditional medium-technology goods – even of highest quality – a focus on three aspects seemed reasonable: to create and support conditions for successful independent fundamental innovations, to upgrade existing technology in general by marginal innovations, and to concentrate on a limited number of innovative high-tech-market segments (“niches”), in which fundamental Austrian innovations and consequently Austrian *market leadership* appear likely.

After several steps in this direction (e.g. the design of a comprehensive strategy for technology policy; a number of priority programs in several high-technology fields), *national technology policy* was looking for new ways to stimulate the national innovation system effectively. The selection of priority areas was also seen as a problem and a concentration on a top-down approach proved less and less promising. Having got interested by foreign examples, the Ministry of Science and Transport decided to plan and commission a *Foresight* exercise which should be tailored to the specific needs of Austria.

The task of the Austrian Foresight exercise differed markedly from that of most of its foreign predecessors. Technologically leading countries such as the U.S., Japan or Germany used Foresight to search for emerging technologies, to concentrate their innovative efforts on emerging markets and to profit from first mover advantages. For Austria, however, a search for these emerging technological trends did not seem advisable – Austria can utilise the results of foreign Technology Delphi-studies. What has to be sought for are the *market segments and niches* within these worldwide emerging markets, in which specific Austrian advantages in R&D, skills and production facilities provide good starting position for successful innovations, i. e. innovations promising a good chance for future Austrian leadership in these very niches.

This situation shaped the *overall goals* and the approach of the Austrian Foresight exercise: It had to be above all problem- and demand oriented, responding to actual societal needs, and at the same time heading for the identification of most promising areas of innovation in which Austria could hope to achieve a leading position both in R&D and in terms of economic success. Further objectives right from the outset were to build on a bottom-up flow of expertise and it was also clear that the Foresight should not deal with technology only; the Technology-Foresight should also include organisational innovations and was to be combined with a Society and Culture Foresight as a consequence of the declared demand- and problem-orientation. Finally, the Austrian approach aimed at producing information to be implemented through technology policy-making and at concentrating the Foresight efforts on a selection of areas with particularly high priority.

It was in autumn 1996 when this first initiative to a systematic *Foresight process* on a *national level* in Austria was launched. The approach which was developed for this Foresight task entailed a number of innovative elements whereby two Delphi-processes represented a core instrument. They will be outlined in the following together with a brief overview on execution, major outcomes and impacts to date. To give an impression of the main *building blocks* of the Austrian Foresight programme, its organisation as a whole is summarised in *Figure 1*.



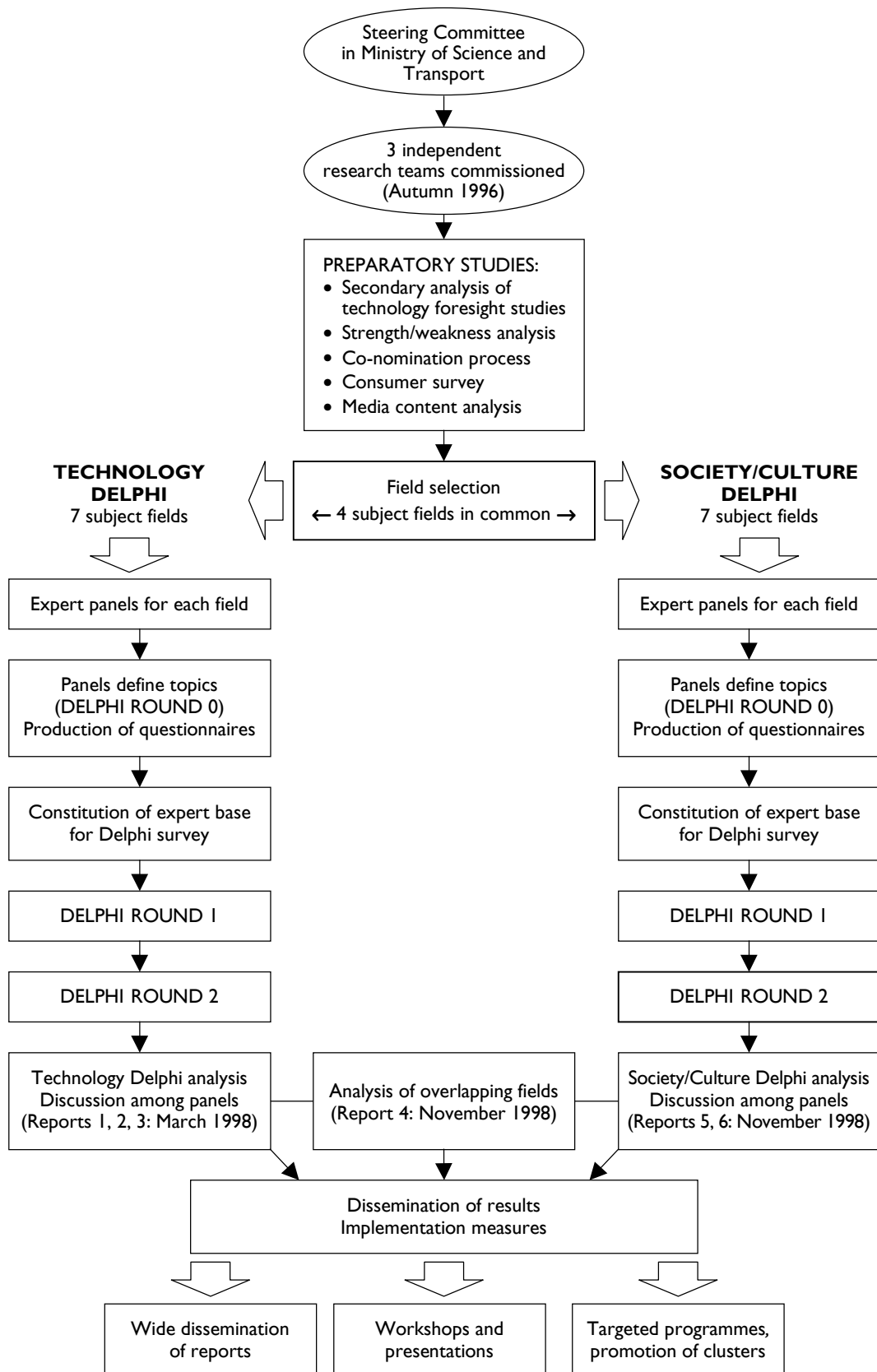


Figure 1: Organisation of the Foresight Programme “Delphi Austria”

## 4 Execution of the Technology Foresight

The *Ministry of Science and Transport* (now Ministry of Transport, Innovation and Technology)<sup>1</sup> commissioned different parts of the Foresight Programme “Delphi Report Austria” to three external research teams and established a small *Steering Committee* at the ministerial level (some chief executives from different departments of the Science Ministry, a representative of the Austrian Academy of Sciences and a science journalist with experience as a former Minister).

Essentially, the Foresight Programme “Delphi Report Austria” consisted of a series of preparatory studies, a number of expert panels, a Technology Delphi and – as a quite unique feature – a combination with a Society and Culture Delphi<sup>2</sup>. The *selection of areas* on which the Foresight should concentrate and the topics within the field were of utmost importance. To solve this task, the main stage of the Austrian Foresight exercise was preceded by several other foresight-oriented *preparatory studies*. The work of defining suitable subject fields was, however, less focused on technological development, to avoid the frequent trap of new technologies urgently searching for application; rather it was *problem-oriented*, assuming that innovations with a potential to solve existing problems will also more easily find a market in the future, as is described by Tichy (1999):

“The set of Austrian foresight studies started with an *analysis of the existing foreign (Classical) Delphi studies*, to evaluate the predicted world-wide technology trends. Only those trends were considered as relevant for Austria which showed up in already existing Austrian strengths. To find these already existing strengths of the Austrian technology sector, the economic *literature was surveyed* and 350 *experts* (response rate 39 %)<sup>3</sup> *were interviewed*. Sectors leading in R&D were found to be medical science, environmental techniques and materials, sectors leading economically proved to be environmental techniques, physical mobility and materials. In all these fields the experts indicated good co-operation between academia and firms in addition to high competitive performance. The same survey and the same sample of experts was used for a *co-nomination study*, searching for the networks of appropriate experts, as a basis for selecting the experts for the working panels responsible for elaborating the questionnaires as well as for the respondents of the later Delphi survey. All these preliminary studies did, however, not suffice as they concentrated on supply while the Austrian Delphi study ought to give an at least equal weight to demand. Methods to forecast long-term demand for high-tech goods, however, are still lacking. Two proxies, therefore, were utilised: A consumer survey and a media analysis. The *consumer survey* indicated a high acceptance of research in the fields of medicine, environment, energy and materials on the one side, and a heavy resistance against research in gene- and communications-technology. More than half of the respondents would not consume genetic modified food, even if it is better, and almost two fifth favour the production of bio-food, even if it is more expensive. The *analysis of opinion-forming media* yielded medicine, computer and telecommunication as the subjects most frequently dealt with, followed by biotechnology/genetic engineering and space-research. As an important non-technical cross-sectional area pragmatics of every-day life (“Alltagspragmatik”) showed up.”

On the solid basis of these six studies the Austrian Foresight exercise arrived at the *selection of subject fields* for the Technology Delphi. The following criteria were applied in the selection proc-

<sup>1</sup> See the figure showing the present institutional set-up of the Austrian technology policy at the end of the appendix.

<sup>2</sup> The Technology Foresight part was designed and carried out by the Institute of Technology Assessment (ITA) of the Austrian Academy of Sciences, while the Institute of Trend Analysis (ITK) in Vienna was responsible for the Society and Culture Foresight.

<sup>3</sup> Of which 17 % entrepreneurs, 23 % physical scientists, 16 % technicians, 13 % social scientists, 19 % administration.

ess in co-operation between the research teams and the Steering Committee: positive world-wide trend, capacity to solve problems, presumed high future demand, early stage of the product cycle, already existing strengths of Austria, complexity of the product or the process, acceptance by the population, sufficient differentiation of fields (portfolio aspect) and sufficient size of the field. A wide definition of technology was applied, including also organisational innovations.

The resulting fields which were attributed highest priority and hence should be *subject areas* of the Technology Foresight exercise are the following:

1. New forms of housing and environment-oriented construction,
2. Lifelong learning,
3. Medical technology and support for elderly people,
4. Clean and sustainable production,
5. Organic food,
6. Physical Mobility,
7. Characteristics-defined materials.

The combination with the subject fields of the Society & Culture Delphi will be described in the course of the next chapter. In total, the Austrian Foresight exercise comprises *seven fields studied in each of the two combined Delphi processes*, i. e. the Technology Delphi and the Society & Culture Delphi.

For each of these fields *expert panels* were established of up to two dozen members consisting of professionally experienced persons with high levels of competence, largely belonging to the decision-making hierarchy in science and research, business, public administration as well as intermediate interest organisations (including NGOs, consumer organisations and user representatives). These panels were key to the intended bottom-up creation of the contents of Foresight, i. e. visions of innovations promising Austrian lead positions and of corresponding support measures. Next steps were the *nomination* of a large amount of experts in each field (and the *generation* of an associated address base) who should later assess the hypothesised innovations as respondents in the large Delphi surveys. The results of these two Delphi-rounds were statistically analysed by the research teams responsible and the outcome was summarised in a series of reports as the main products of the Foresight exercise.<sup>4</sup>

<sup>4</sup> The results of the *Technology Foresight* comprise volume 1, 2 and 3 of the series *Delphi Report Austria*. Volumes 4, 5 and 6 of this series contain the results of the *Society & Culture Foresight* and the cross-cutting analysis. All volumes are in German and available at the Austrian Ministry of Science and Transport (contact: Mag. Erfried Erker, Tel.: ++43 1 53120-7171; e-mail: [Erfried.Erker@bmwf.gv.at](mailto:Erfried.Erker@bmwf.gv.at)). They can also be downloaded via the following Internet address: <http://www.bmv.gv.at/tech/delphi/index.htm> - Downl. A summary report in English will be announced at: <http://www.oeaw.ac.at/ita/>.

## 5 The Combination of a Technology Delphi with a Society and Culture Delphi

The missing consideration of the broader societal context of technical change has turned out to be a gap in earlier Technology Foresight studies. For instance, already the first German Delphi study had concluded “that technological developments should not be investigated and assessed in isolation from social and cultural circumstances” and that “the question of social desirability has to match the question of technical feasibility” (BMFT 1993). Among others, a “Social Technology Foresight” had also been explicitly suggested in relation with decreasing acceptance of products and technology development programs in society (Todt/Lujan 1998).

In the Austrian Foresight exercise, the inclusion of societal aspects was one of the principles guiding the whole approach (ITA 1998a). This is reflected by the design and questionnaire contents of the Technology Delphi itself as well as the idea to match the Technology Delphi with a Society & Culture Delphi. This combination was motivated by the objective to shed light on the *social embedding* of the various technical and organisational innovations and to examine different scenarios of social and cultural developments expected by experts in the short, middle and long term.

The two strands of Delphi studies in the Foresight Programme overlap in terms of subject areas: out of the seven fields of the Technology Delphi and the seven areas of the Society and Culture Delphi, four focus on the same subject area. This combination was regarded as a reasonable mix of technology-specific and general scope of societal developments. These overlapping fields include: New forms of housing and living; Lifelong learning; Medical technology and health; Clean and sustainable production (Fig. 2).

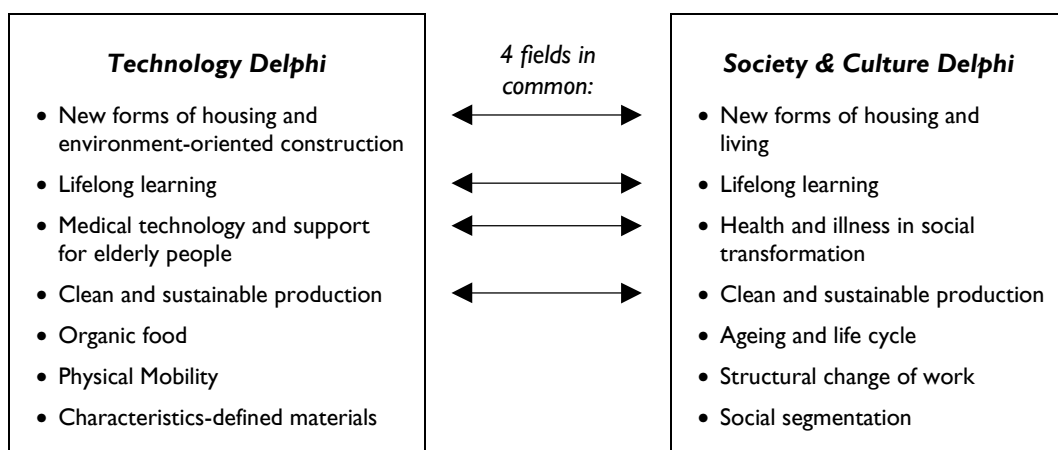


Figure 2: The subject fields of the Austrian Foresight Program

The particular objectives pursued by the *Society & Culture Delphi* were the following ones (ITK 1998): to map social, cultural, economic and political trends within the Austrian society; to assess the societal and political significance of each of the trends; to assess impacts of societal trends on research and development as well as in terms of priorities for politics; to identify conflict potentials of societal trends and finally, to assess the desirability of trends as perceived by Delphi experts.

To give a few examples of the results obtained in the subject field “Health and illness in social transformation”: Most important trends are an increasing awareness of and interest in prevention; a

growing importance of research on diagnostic and therapeutic strategies in the area of chronic disease; a split into high-tech medicine in central hospitals and treatment of patients with chronic disease in hospitals with less sophisticated equipment, or in day care centres and at home; and a wide diffusion of voluntary service throughout the health care system. Highest priority for research and development was attributed to: electronically networked health centres which co-ordinate research via data networks, enable tele-consultations and exchange results, patient related data and expertise of consultants on-line; diagnostic and therapeutic strategies in the area of chronic disease with a corresponding upgrading of the image of chronic patients; and an intensified health education in families, schools and companies, leading to increased interest in prevention. As trends deserving highest political priority were identified: a potential break-down of the solidarity principle in health insurance (which is also seen as one of the highest conflict potentials); then again the increasing interest in prevention; psycho-social support services for long-term unemployed people; a predominance of cost-benefit analyses in the medical system; and also the split between central high-tech hospitals and marginalised chronic patients. Finally, further trends which are attributed major conflict potentials are increasing financing problems and difficulties for planning in the health care system; an increasing codification in law of the doctor patient relation as a source of rises in price; the dominance of cost-benefit analyses in the medical system; and discussions on the issue of euthanasia.

The emerging split between areas of acute treatment with high-tech equipment in a few centres on the one hand and external treatment of chronic patients on the other hand is one of the central themes in this subject field. Increasing polarisation turned out to be a trend also in other subject fields of the Society and Culture Delphi (work, housing, information and new media, gender). Further trends which are suggested by the experts' assessments as dominant across several fields are: a change of the demographic structure towards the elderly with impacts on the generation contract, health care, housing and living; increased outsourcing in all service sectors and a role for decentralised networks; a preservation of the state's governance function, e. g. in environment policy and education policy; at the same time increased importance of the civil society through new forms of community action; and a continued role for national level policies complemented by European Union and regional policies.

As concerns time horizons, the assessments of trends for the next 5 to 15 years are characterised by a surprising continuity of the societal status quo. However, within a horizon of 15 to 30 years quite a profound structural change of the Austrian society is expected to occur. The authors of the report (ITK 1998) interpret this contrast as an alarming time-lag between unsolved social problems and successful coping with them.

The matching of the questionnaire contents of the two Austrian Delphi exercises executed in parallel also allowed for a synthesis of the results of the four overlapping subject areas. This analysis concentrated on a number of cross-cutting themes which were seen as major elements generating change: service economy; science industry; information and communication technologies (ICT); and market opportunities (Rust 1998). The overall picture emerging from this synthesising view is a somewhat muted modernisation profile for the next 15 years: A number of technical and organisational innovations will impact on everyday lives and business but the basic institutions of the existing social market economy and public services will remain unchanged. Traditional values like regional identity and public financing of health, education and other public services will be preserved. In none of the areas under investigation does technical change take on revolutionary forms. The health and medical system is one of the areas with particular innovation potentials with impulses for aspects of service economy, science industry and ICT as well as market opportunities.

## 6 The Design of the Technology Foresight as a Decision Delphi

According to Rauch (1979) it is useful to distinguish three types of using the Delphi-method: Classical, Policy and Decision Delphi. He called the traditional Delphi approach a *Classical Delphi*: It seeks to obtain a group opinion through an anonymous, multilevel group interaction in the form of a conditional scientific prognosis. Preconditions for the reasonable application of a Classical Delphi are developments following explicit laws or at least certain regularities. Such an environment is often lacking in social systems, but also in technological development.

By contrast, a *Decision Delphi* is an instrument to prepare decisions and to influence social developments: “reality is not predicted or described; it is made” (Rauch 1979: 163). A Decision Delphi is also described as more appropriate in fields which are shaped by a mix of individual decisions rather than by general rules or regularities. If developments are dominated by a multitude of independent and uncoordinated decision makers, a Decision Delphi is recommended to structure and co-ordinate them towards a path to a desired future situation. The participants of a Decision Delphi are recruited primarily with regard to their actual position in the decision-making hierarchy and in the second instance to their expertise.

It has been pointed out that the goal of the Austrian Foresight exercise was not to detect the general outlines of emerging technologies but to map out those fields and niches, in which Austria could reach a leading position within the next 15 years, either in R&D, in economic exploitation or in social and organisational implementation. For this task of field identification a Decision Delphi was regarded the appropriate tool:

As Tichy (1999) argues, these fields “are not so much determined by technological development and economic laws, but by the decisions and the efforts of numerous scientists, entrepreneurs and managers, by their expectations, uncertainties and actions or non-actions. The participation of these persons in a Decision Delphi is part of a foresight exercise as well as part of ‘making of the future’: Answering the questionnaire in the *first round* forces the decision makers to deal explicitly with probable future developments, a subject normally deferred to the Greek Calends, to the never-never time of less urgent business. Answering the questionnaire in the *second round* confronts the decision-makers with the evaluations of their colleagues and competitors, and allows them to adapt their own assessment anonymously, thereby probably creating some form of consensus and implicitly formulating a national path of development and specialisation. The results may or may not be acceptable for the governments’ technology concept; they can, however, provide a basis for policy action in any case”.

According to the bottom-up approach inherent in a Decision Delphi and the necessity to involve decision-makers as much as possible, heavy weight was given to the *expert panels* in this design. They prepared the topics and questions used in searching for promising innovations. This input formed the basis for questionnaires which were then responded by a much wider group of experts in a two-stage Delphi survey. In particular, the task of the expert panels was to formulate around 40 hypotheses on promising innovations in a 15 years time horizon in each field (e. g. “Simulation-software for virtual optimisation of vehicles and their components with respect to weight, safety, and emissions will be developed”).

Special emphasis was laid on orientating the visions of innovations towards a *successful realisation in Austria*, and on *specific support measures* to achieve this goal. This latter aspect has to be seen as a deliberate attempt in arriving at a “higher degree of finalisation” of policy measures than other Foresight exercises had done so far. For this purpose, the expert panels had to compile lists of concrete policy instruments for appropriate groups of innovations, likely to improve the chances of Austrian leadership.

The *questionnaires* for the Delphi surveys were then designed in detail by ITA: For any one of the around 40 hypothesised innovations within each of the seven fields, the respondents indicated, a) their specific knowledge and, b) gave assessments on the following dimensions:

- the degree of innovation implied in the respective vision,
- its importance (for society, economy and environment),
- the chances of realisation in Austria in general,
- the chances of Austrian leadership with respect to:
  - R&D,
  - organisational and social implementation, as well as
  - economic exploitation,
- the desirability of the development in question.

In addition, the respondents should indicate which policy measures – out of a given list – they considered as appropriate to enforce the envisaged development. Moreover, room for open comments was also provided (see Annex I and II for examples). Further to that, 17 so-called “mega-trend” questions tapping on more general societal and global developments as a background to the innovation processes in question were posed to all respondents.

The *respondents to the Technology Delphi* were selected according to their expertise and an intended equal composition of the sample constituted by three broad categories: academia, business and a category comprising administration and groups of lobbyists in equal parts. The co-nomination study served as the main pool of experts and was complemented by persons nominated by the basic expert panels. In addition, a number of other sources were used to fill the remaining gaps to reach by and large a composition of the sample close to equal proportions of the three categories outlined (see tables in Annex III).

The Austrian Technology Delphi consisted of two rounds, like most other Foresight exercises of this kind: 3748 *questionnaires* were mailed in the first and 1597 in the second round, 46 % and 71 % of which were returned. Out of the respondents of the second round about one third were employed in firms, a quarter in academia; in terms of function, one third worked in R&D and management respectively, one eighth indicated a combination of several functions. Women were heavily underrepresented while the age structure was rather balanced.

The decision Delphi approach and the combination with a Society/Culture Delphi were not the only innovations of the design of “Delphi Austria”. Also the broader conception of the expert base deserves to be pointed out as an integral component: The composition of the expert base for the Delphi surveys aimed at including not only research and technology experts but also an adequate share of what can be circumscribed as “practical user-”, “public management-” and “market-related” expertise. However, an absolute requirement for an assessment to be taken as valid has been at least a medium level of expertise in the innovation in question.

## 7 Assessment of “Mega-Trends” and Profile of the Expert Base

In the latest German Delphi study (Cuhls et al. 1998) an assessment of some general societal trends on the national as well as global level – a so-called *mega-trends* section – was added to each field-specific questionnaire of a Technology Foresight for the first time. This novel element served the aim to control for more general visions of the future and world-views among the respondents. Participants of the Delphi exercise in each field were invited to respond to the same set of 19 statements on general (economic, social, political, cultural, environmental) trends world-wide and in relation to the national context.

In the Austrian study, this tool was used in a slightly modified way. It should serve *three functions*: first, the world views of the respondents to the Technology as well as the Society and Culture Delphi should be examined and compared; second, the general attitudinal profile of the Austrian experts should be assessed by way of comparison with that of the experts of the German Delphi; and third, it should enable a control for two potential subjective biases of the experts’ assessments: a) a bias due to particular world views, and b) a bias due to vested interests in a particular area. For these purposes the list of items used in the German study was partially adapted: The same items as in Germany were presented to the participants in the Austrian Society and Culture Delphi whereas for the respondents to the Technology Delphi seven more global statements of the German list were replaced by newly created items; each of these described a key trend in one of the seven subject areas. The idea was to have a possibility to compare, with respect to key trends, the views of field experts with assessments by experts from all other fields as an – admittedly rough – check for a potential interest-based bias.

To put it short: Six different types of *world-views* were identified among the respondents of the Technology Delphi. They largely reflected optimism or pessimism vis-a-vis economic and ecological trends, national sovereignty and societal progress. A comparison with results from the German study showed a considerable similarity of assessments of general trends and confirmed the balanced mix of Delphi experts. Some field-specific subjective bias could not be excluded in all subject areas but was not found to impact on the assessments of particular innovations in a significant way (see Aichholzer 2001).



## 8 Main Results and Impacts

The analytical *findings* and *implications* derived from the results of the Austrian Technology Foresight for technology policy can be summarised as follows:

In certain areas Austrian research institutions or firms already have achieved *leadership* or have the potential to do so in a middle range perspective, especially through the application of high – if not highest – technology in otherwise medium technology fields and, on the other hand, in markets in which Austria has lead market character (e. g. in clean technologies, organic food) because of a special demand situation (shaped for instance by the legal regulation, characteristics of the social system, consumers' preferences etc.). In general, however, Austria has not yet accomplished the leap from a technology adopter to a technology developer.

*Special opportunities* to achieve leadership exist in the following areas:

- Simulation models in construction processes
- High-tech steel and low weight materials
- Recycling of composite materials and mixed materials
- Low noise equipment for railways
- Cleaner production technologies (especially in metal and paper production)
- Wood as material in constructive applications
- Ecologically sound construction
- Organic food (seeds and breeding, conservation and analysis techniques)
- Technologies supporting life-long learning (tailor-made packages for further training, intelligent information agents, electronic learning media)
- Technologies supporting an independent living of the elderly without losing personal contacts
- Substitutes for organs and functions (in conjunction with bio-compatible materials, hybrid technologies).
- Information and communication technologies are part and parcel in almost all cases of successful or potential leadership, as independent technologies they only play a role in certain niches.

The Foresight studies also identified major *problem areas*:

A specific problem is that the time horizon anticipated and taken into account in innovation activities by firms and applied research is too short. It also became clear that isolated technological efforts are not very likely to pay off: Success in achieving leadership requires a wider approach, networking, co-operation between firms and research institutions, a linking of technical and organisational innovations and a critical mass of firms and research institutions. Attitudes towards organisational innovations turned out to be more ambivalent, indicating a higher level of mistrust in their feasibility.

As concerns *policy options*, the most important measure suggested by the Technology Foresight is the strengthening of co-operation between research institutions and firms as well as among firms and research institutions themselves. Recommended measures include: actions promoting the development of clusters in future oriented core areas, the creation of new institutions for the coordination of interdisciplinary research focuses, a differentiation in research promotion between more routine and high risk long-term projects, the prescription of targets and continuous evaluation in project promotion and the setting up of pilot projects, especially on organisational innovations. For each of the seven sectors a plenty of more specific policy recommendations can be found in the volume devoted to sector-specific results of this Technology Foresight (ITA 1998b).

Three years after completion Delphi Austria achieved some real and measurable impacts. *Direct impacts* (i. e. policy measures) can be observed in the form of implementation of policy measures, initiated by the Science Ministry. The following overview shows that several of the subject fields Delphi Austria's are matched by such implementation measures:

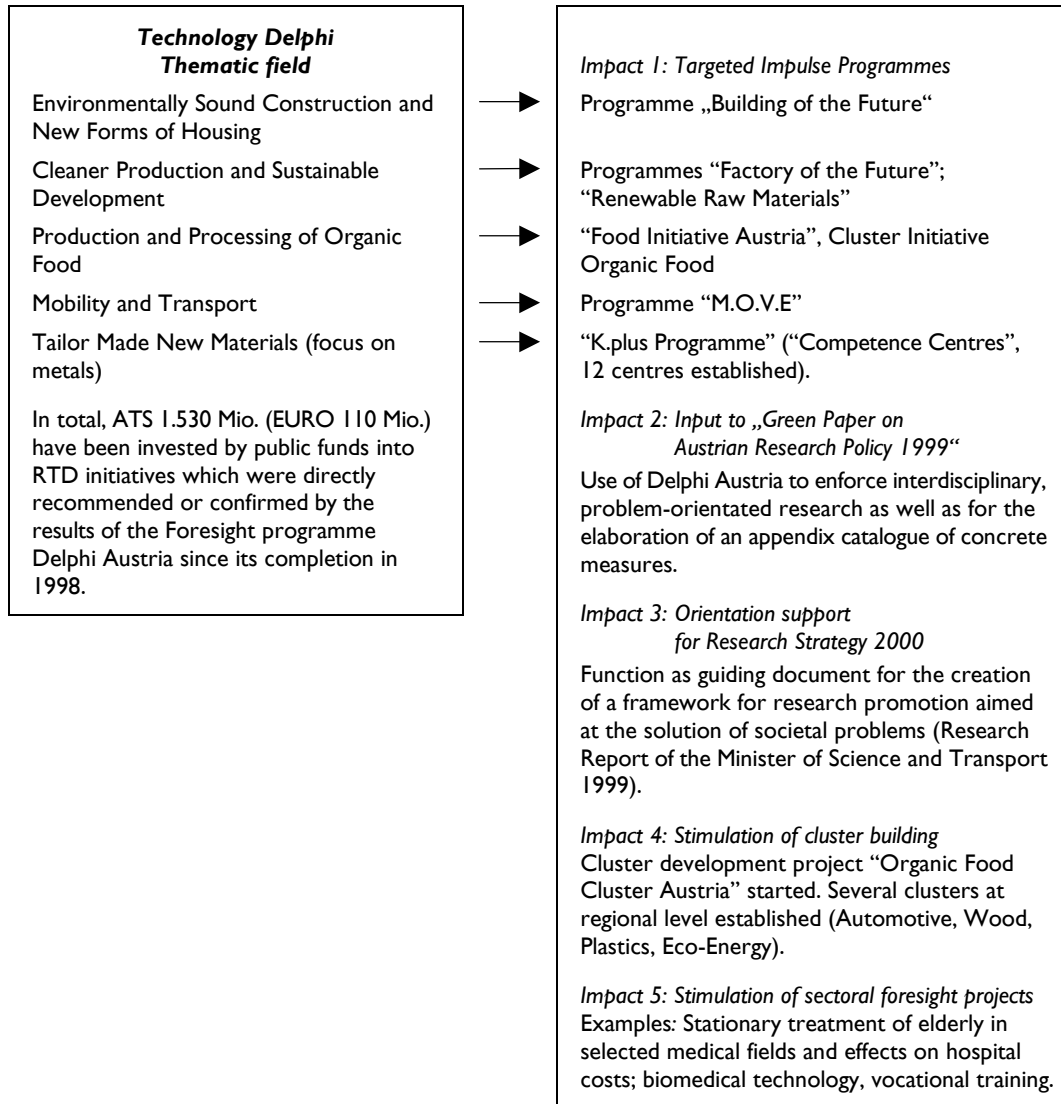


Figure 3: Impacts of the Austrian Foresight Programme

Three targeted programmes are sub-programmes of the programme for “Sustainable Development”: “Building of the Future“ and “Factory of the Future” are already in operation, “Renewable Raw Materials” is about to be launched. The programme ‘K.plus’ has established 12 ‘Competence Centres’ (centres of excellence) since 1999 which pursue a strategy of promoting co-operation between firms and research institutions on major innovative projects in a pre-competitive stage. They also support the development of clusters in promising areas. The majority of centres within this programme work in areas suggested by Technology Foresight results (e. g. new materials, wood technologies, applications of information technologies). Also at least one new research facility of the Christian Doppler Laboratories was established in a field suggested by Delphi Austria (Wood Research).

It has to be said, however, that a causal relationship cannot be postulated in all cases, but at least such measures are confirmed by results of Delphi Austria. On the other hand, some initiative has been stimulated by way of self-organisation. A case in point are the creation of the programmes 'Building of the Future' and 'Factory of the Future' which originated from the organisation of a participant in the Technology Delphi.

A further important impact concerns the new research strategy programme ("Österreichische Forschungsstrategie 1999plus") adopted after the discussion of a green paper based on "Delphi Austria". It has among others strongly influenced strategic programmes at regional level such as in the Province of Upper Austria (several clusters have been set up).

Finally, more or less directly related with panel activities, independent Foresight projects have been triggered in the fields of vocational training and retraining, mobile communications, medical technologies, and transport. For instance, a study on the "Future of vocational training and retraining" has been undertaken by the Institut für Berufs- und Erwachsenenbildung at the University of Linz (IBE) within the framework of an international study commissioned by the European Foundation for the Promotion of Vocational Training (CEDEFOP), Berlin.

Although a systematic evaluation in a formal sense has not been undertaken, an internal assessment of impacts of Delphi Austria by the Ministry of Science is provided. It lists the measures stimulated by Delphi Austria and uses of results by different agencies. It includes a quantification of the leverage effect in terms of the volume of promotion measures which amounted to 1.530 million ATS (110 million EURO) by late 1999 (which is around one year after the completion of the last of a series of Delphi reports).

On the other hand, one can see the following *indirect impacts* two years after completion of Delphi Austria:

The results of the Austrian Foresight Programme are built on a sufficiently broad basis of expertise to be used as an important information source for technology policy-making as well as other actors of the innovation system, especially in companies and research institutions. The process of involving a great number of these actors, either as members of one of the panels developing the contents of the Delphi questionnaires or as participants in the Delphi rounds themselves, has already been a deliberately promoted and valuable result of the whole Foresight programme. Further steps in that direction have been undertaken first of all with the wide diffusion of the results of "Delphi Austria" on the national level. Several thousands of copies of the reports have been distributed among business, academia, public administration and other organisations in spring and towards the end of 1998. All reports are accessible via the website of the Austrian Ministry of Transport, Innovation and Technology on the Internet and can be downloaded, including the tables containing the quantitative results. A number of major presentations and workshops have complemented this diffusion process which also has led to the wide circulation of a number of contributions both in print media (several newspapers and magazines) as well as on radio and TV.

This means that with the Foresight process itself and the dissemination of its results a contribution to the stimulation of co-operation and networking has started. It can be expected to be continued with ongoing and future sectoral activities and to contribute to what is meant by 'wiring up the national innovation system'.

## 9 Summary and Conclusions

It has been shown that Technology Foresight programmes are flourishing, especially among small countries, in the nineties. Such exercises have been taken up also by transition countries and seem to be a useful instrument for them indeed when tailored to the specific needs of the country. Goals and approaches are generally different and need to be adapted to the particular position in the global economy as well as they need to respond to national problems. Experience to date indicates that even among small countries the approaches are quite varied. However, the scopes of foresight exercises are more frequently oriented at specific national conditions and the identification of niche potentials, time horizons are less long-term, more emphasis is laid on the foresight process itself and bottom-up approaches tend to be favoured.

The Austrian Foresight Programme “Delphi Austria” is a typical example of a small country approach. It was tailored to the present stage of economic and societal development and should serve as a strategic intelligence input to a mid- to long-term oriented technology policy. Therefore the approach put emphasis on a problem- and demand-driven orientation, applicability of results and on strengthening the links among the national innovation system.

The Technology Foresight definitely used a bottom-up approach including expert panels and Delphi exercises as key elements which had mainly two tasks:

- a. to identify and assess those areas of innovation with high importance in the next 15 years in which Austria could achieve a leading role and,
- b. to consider and assess a variety of measures for each group of innovations to support this goal.

The Technology Foresight led to the identification of a number of promising innovation areas and policy measures. Around a dozen such areas have been pointed out as most likely to allow Austria to achieve a lead position in R&D and market segments. Matching the Technology Delphi with a Society and Culture Delphi shed some light on the social embedding of the various technical and organisational innovations. A perspective emerging from this synthesising view is a somewhat muted modernisation profile in Austria. The assessment of some general societal trends which had been first introduced in a German Delphi study was used in a novel context and allowed to examine the homogeneity of the expert base.

The Austrian Foresight results are built on a broad basis of expertise and accessible for technology policy-making as well as other actors of the innovation system, especially in companies and research institutions. A great number of these actors has been involved in the Foresight process, either as panel members or as respondents to the Delphi questionnaires in two survey waves. This has already been a deliberately promoted and valuable result of the whole Foresight programme.

The results of “Delphi Austria” have mainly had considerable direct impact in shaping central technology policy measures so far: They have stimulated the start of new targeted programmes in the field of sustainable production, influenced the selection of subject areas of “centres of excellence” for promotion as well as of cluster building at national and regional levels.

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## ANNEX I: Innovation Statement (questionnaire sample page)

### I. **Biological digestion processes are used for pulp production instead of sulphite or sulphate processes in order to reduce the specific energy demand**

(in the cases of a.– d.: **insert applicable number**)

Assessment scale: 1 = very high    2 = rather high    3 = medium  
4 = rather low    5 = very low

- a. My general **expertise** concerning this thesis is \_\_\_\_\_
- b. The **degree of innovation** of the development mentioned in the thesis is \_\_\_\_\_
- c. The **importance** of this development is \_\_\_\_\_
- d. The **chance of realization** in Austria within the next 15 years is \_\_\_\_\_

(in the case of e. and f.: please mark with  a **cross**)  
(in the case of e.: multiple answers possible!)

- e. **Austria has good chances** especially regarding \_\_\_\_\_  research & development \_\_\_\_\_  organisational- societal implementation \_\_\_\_\_  commercial exploitation
- f. I consider the development described as \_\_\_\_\_  desirable \_\_\_\_\_  not desirable

Comments:

## ANNEX II: Policy Measures (questionnaire sample page)

**How high or low do you assess the suitability of the following measures to increase Austria`s chance to have success in the cases of the most promising innovations in the area of Cleaner Processes?**

Assessment scale: 1 = very high      2 = rather high      3 = medium  
 4 = rather low      5 = very low  
 (please mark with a cross in every case )

- Strengthen basic research \_\_\_\_\_ ① ② ③ ④ ⑤
- Increase the use of simulation methods (EDP) for the development of processes and materials \_\_\_\_\_ ① ② ③ ④ ⑤
- Strengthen application oriented process and material development \_\_\_\_\_ ① ② ③ ④ ⑤
- Establish and support pilot plants \_\_\_\_\_ ① ② ③ ④ ⑤
- Reduce capital raising costs \_\_\_\_\_ ① ② ③ ④ ⑤
- Increase financial support for developers and users \_\_\_\_\_ ① ② ③ ④ ⑤
- Support opening up new markets \_\_\_\_\_ ① ② ③ ④ ⑤
- Simplify existing support procedures \_\_\_\_\_ ① ② ③ ④ ⑤
- More steady and long-term oriented environmental policy \_\_\_\_\_ ① ② ③ ④ ⑤
- Realise of an ecological tax reform \_\_\_\_\_ ① ② ③ ④ ⑤
- Increase transparency of environmental regulation \_\_\_\_\_ ① ② ③ ④ ⑤
- Strengthen co-operation between basic research and application oriented research \_\_\_\_\_ ① ② ③ ④ ⑤
- Strengthen co-operation between process or material producers and users \_\_\_\_\_ ① ② ③ ④ ⑤
- Support co-operation between different areas of processes and materials \_\_\_\_\_ ① ② ③ ④ ⑤
- Strengthen co-operation between application oriented research and process and material producers \_\_\_\_\_ ① ② ③ ④ ⑤
- Strengthen the training of process and material users \_\_\_\_\_ ① ② ③ ④ ⑤
- Increase the sensitivity of the public with respect to cleaner processes \_\_\_\_\_ ① ② ③ ④ ⑤

Other *important* measures:

*Space for comments to the area „Cleaner Processes“:*



## ANNEX III

*Table 1: Composition of expert panels and participants in Technology Delphi*

	Panel members		Delphi respondents	
	N	%	N	%
Science	42	34	321	25
Business	53	41	451	35
Administration	21	16	214	17
Interest organisations	12	9	90	7
Other	–	–	209	16
<b>Total</b>	<b>128</b>	<b>100</b>	<b>1285</b>	<b>100</b>

*Table 2: Numbers of participating experts in Technology Delphi (round 2)*

Area	Questionnaires delivered N	Questionnaires for analysis N	Response rate %
Lifelong learning	301	219	73
Environmentally sound construction and new forms of housing	216	142	67
Medical technologies and supportive technologies for the elderly	191	139	74
Cleaner production and sustainable development	302	211	71
Tailor-made new materials	121	90	75
Mobility and transport	290	200	70
Production and processing of organic food	176	126	72
<b>Total</b>	<b>1597</b>	<b>1127</b>	<b>71</b>

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